

SURFACE-WATER MONITORING ACTIVITIES - Updated August 2000

Surface-water-quality monitoring activities in the NECB study unit during 1998-2001 are intended to focus on the following issues:

- Nutrient loading to coastal waters where eutrophication is a major water-quality concern in the New England region; this would be accomplished through placement of four integrator sites (sites selected to integrate the water-quality impacts of a variety of land uses);
- Effects of gradients of urbanization on water quality and aquatic ecosystems; this would be accomplished through placement of six indicator sites (sites selected to represent areas with relatively homogenous land use) and participation in a pilot land use gradient study with the NAWQA Ecological Integration Program;
- Contamination of bed sediments and fish tissues with an emphasis on mercury; this would be accomplished through both the bed sediment and tissue (BS&T) occurrence survey and a study unit mercury study; and
- Other specific-objective synoptic studies that would be identified in 2000 and carried out in 2001.

Each of these issues are described below in relation to the main types of surface-water activities (basic/intensive fixed site network, bed sediment and tissue occurrence survey, mercury study, and other special/synoptic surveys). A schedule of surface-water activities is presented in table 1:

Table 1: Schedule of surface-water monitoring, 1998 through 2001

Surface-water component	1998	1998-99				1999-00				2000-01			
	JAS	OND	JFM	AMJ	JAS	OND	JFM	AMJ	JAS	OND	JFM	AMJ	JAS
BS&T occurrence survey													
Basic Fixed site network													
Intensive fixed sites													
Urban land-use gradient study													
Mercury study													
Other Surface Water/Ecological Synoptics													

The majority of surface-water-quality activities are proposed to occur in drainages entirely or primarily located in the Northeastern Coastal Zone ecoregion because it contains over 80 percent and 90 percent of all urban and new urban lands, respectively, in the study unit. This translates into greater population and drinking water use in this ecoregion than the other ecoregions. Focusing on streams in the Northeastern Coastal Zone will allow the study to provide more thorough assessments of the effects of new urban land uses on stream water quality and aquatic biota. Our Liaison Committee identified these effects as being of great importance and, recently, USEPA-New England Region has made this issue a regional initiative.

FIXED SITE MONITORING PROGRAM

For more information on the fixed site monitoring program contact Keith Robinson or Kim Campo

The NECB study will have 10 fixed sites during 1998-2000. Of these 10 fixed sites, 4 are integrator sites (one of which is an intensive integrator site), and 6 are indicator sites that represent a gradient of urbanization from 4 to 68 percent urban (1 of which will be an intensive indicator site). Table 2 describes these sites; sites are shown in Figure 1.

Table 2: List of Basic and Intensive Fixed Sites for the NECB Study Unit

Site Type and Name	Station Identifier	Drainage basin size (mi ²)	Percent Urban (MRLC Data)	Monitoring Plans
Integrator sites				
Kennebec R. @ N. Sidney, Me	01049265	5,403	0.9	18x/yr; basic fixed site
Merrimack R. @ Lowell, MA	01100000	4,635	8.5	18x/yr; basic fixed site; pesticides in yr 2
Charles R. @ Watertown MA (new gage constructed in 1999)	01104615	269	30	30x/yr, intensive site, VOC and pesticides, atmosphere quality and deposition of VOCs
Blackstone R @ Manville, RI	01112900	430	18	6x/yr; basic fixed site, supplements on-going qw monitoring
Indicator sites				
Stillwater R nr Sterling, MA	01095220	32	3.7	18x/yr; basic fixed site
Wading R nr Norton, MA	01109000	43	18	18x/yr; basic fixed site
Neponset R at Norwood, MA	01105000	35	30	18x/yr; basic fixed site
Ipswich R at S. Middleton, MA	01101500	45	38	18x/yr; basic fixed site
Saugus R at Saugus, MA	01102345	23	56	18x/yr; basic fixed site
Aberjona R at Winchester, MA	01102500	25	68	30x/yr, intensive site, VOC and pesticides, atmospheric VOC monitoring

The standard list of NAWQA schedules/constituents will be analyzed at all fixed sites; this includes basic field parameters, nutrients, suspended sediment, and organic carbon at all fixed sites. Pesticides and VOCs samples will be collected at the two intensive sites.

Integrator Sites: The four integrator sites represent a range in the environmental settings of the study unit; they are shown in figure 1. One of the sites, the Kennebec River at N. Sidney is a former USGS NASQAN site. The Blackstone River at Manville, RI, is currently monitored 4 times yearly as part of a cooperative USGS-State of Rhode Island network. All other sites have no or limited historical water-quality data. Three of the integrator sites are considered based fixed sites and the fourth site, the Charles River at Watertown, MA, will be an intensive integrator site. Intensive monitoring will occur from October, 1998 - September, 2000. NAWQA sampling at the Blackstone River will be up to 6 times yearly and will focus on collecting higher flow samples which have been under-represented in past monitoring at the site. Long-term gages are present at or near the Kennebec and Merrimack River sites. A new gage was constructed on the Charles River at Watertown MA site in 1999. Flows have to be estimated for the Blackstone River site and this is done on the basis of flows at the closest upstream gage and taking flow measurements for a small tributary.

The Charles River is currently a high priority river for clean-up by the USEPA and the State of Massachusetts. USEPA has committed resources to ensure restoration of water-quality in the Lower Charles River by 2005. As a result, a number of new studies have been initiated in the Charles River Watershed to assess water-quality conditions and pollution sources; some of these studies are being conducted by the USGS MA/RI District. The monitoring performed by NAWQA will tie into these other efforts. Two years of VOC and 1 year of pesticides monitoring will be performed at the Charles River site. VOC sampling in FY99 was year-round with more intensive monitoring during the winter months, as per NAWQA protocols for intensive urban sites. VOC monitoring in FY00 will occur from October 1999 to March 2000. Pesticides monitoring at the Charles River was started in April, 1999 and continued until September, 1999.

Indicator Sites: The philosophy for our indicator sites is to maximize our understanding of gradients of urban lands on water quality and aquatic biota in a similar ecoregion. Therefore, all indicator sites will drain varying proportions of urban land in the Northeastern Coastal Zone ecoregion. Six indicator sites have been selected to represent the range of urban land (table 2 and figure 1).

Potential indicator sites were evaluated on the basis of various drainage basin characteristics; these include size of the drainage area, population density, percent of old and new urban land, presence of point sources (particular major and municipal facilities), occurrence of water supply intakes, and, finally, reconnaissance during the summer of 1998. From these evaluations, a final list of indicator sites was developed. This list is based on the following:

- Population density and amount of urban land are closely correlated for the drainage basins being considered as indicator sites; therefore, the amount of urban land (both new and old) were used to evaluate the level of urbanization in the drainage basins.
- Gaged basins in the Northeast Coastal Zone ecoregion and in the size category of 19-53 mi² were targeted as indicator basins. Keeping our basin size fairly consistent among the indicator sites will facilitate comparisons on the impacts of increased urbanization.
- No or only minor point source discharges are found in the drainage basin.

One indicator site, the Aberjona River at Winchester, is an intensive indicator site. This site was selected

as an intensive site because it contains the greatest amount of urbanization. VOC and pesticides monitoring took place during 1999 and has continued for a second year in 2000. VOC monitoring in 2000 will end in March; pesticides (sch 2001 only) will be bi-weekly from April to September



Hydrologist collecting water sample: from a bridge over the Merrimack River at Lowell, Mass. The sampler lowered with the cable into the river.

The design of our indicator network has promoted NECB study participation with the NAWQA Ecological Integration Program (EIP) in a pilot study to assess gradients of urban land use on stream ecology and water quality. This special study is discussed further in the section “*Urban Gradient Study*”.

Biological Monitoring: In 1999, all the indicator sites were monitored according to NAWQA biological sampling protocols. This included reach delineations, fish community assessment, and macro invertebrate/algal sample collection. Habitat assessments were to be conducted in September 1999 following the completion of the macro invertebrate/algal sample collection efforts. However, high flows resulting from tropical and frontal storms occurred in the second half of September and into October. Higher flows were maintained into the Fall, which prevented the habitat assessments.

Biological monitoring at the six indicator sites will be done in FY00 as part of the urban land use gradient study. This will include habitat, fish, invertebrate, and algae monitoring. A 3rd year of biological monitoring at the indicator sites may be done.

Atmospheric VOC Monitoring: The NECB study will continue to participate with NAWQA VOC National Synthesis Team in assessing atmospheric sources of VOCs to urban streams. During 1999, six sets of atmospheric samples were collected: two at the Charles River at Watertown and four at the Aberjona River in Winchester. Due last year's unusually dry weather conditions, none of these samples were collected during storms. We plan to collect at least six additional air samples this year during routine conditions. In 1999, the USGS collected two precipitation samples at the Aberjona River and intend to collect four or more precipitation samples in 2000. All these samples are coordinated for concurrent collection with surface-water VOC samples. The study unit staff will also work with the VOC National Synthesis Team to analyze the data, prepare reports, and design future studies to enhance the USGS's knowledge of VOC sources.

Map Number	Station Identifier	Name
1	01049265	Kennebec River at North Sidney, Me.
2	01100000	Merrimack River at Lowell, Mass.
3	01095220	Stillwater River near Sterling, Mass.
4	01104615	Charles River above Watertown Dam, Watertown, Mass.
5	01109000	Wading River near Norton, Mass.
6	01102500	Aberjona River at Winchester, Mass.
7	01105000	Neponset River at Norwood, Mass.
8	01102345	Saugus River at Saugus Ironworks at Saugus, Mass.
9	01112900	Blackstone River at Manville, R.I.
10	01101500	Ipswich River at South Middleton, Mass.

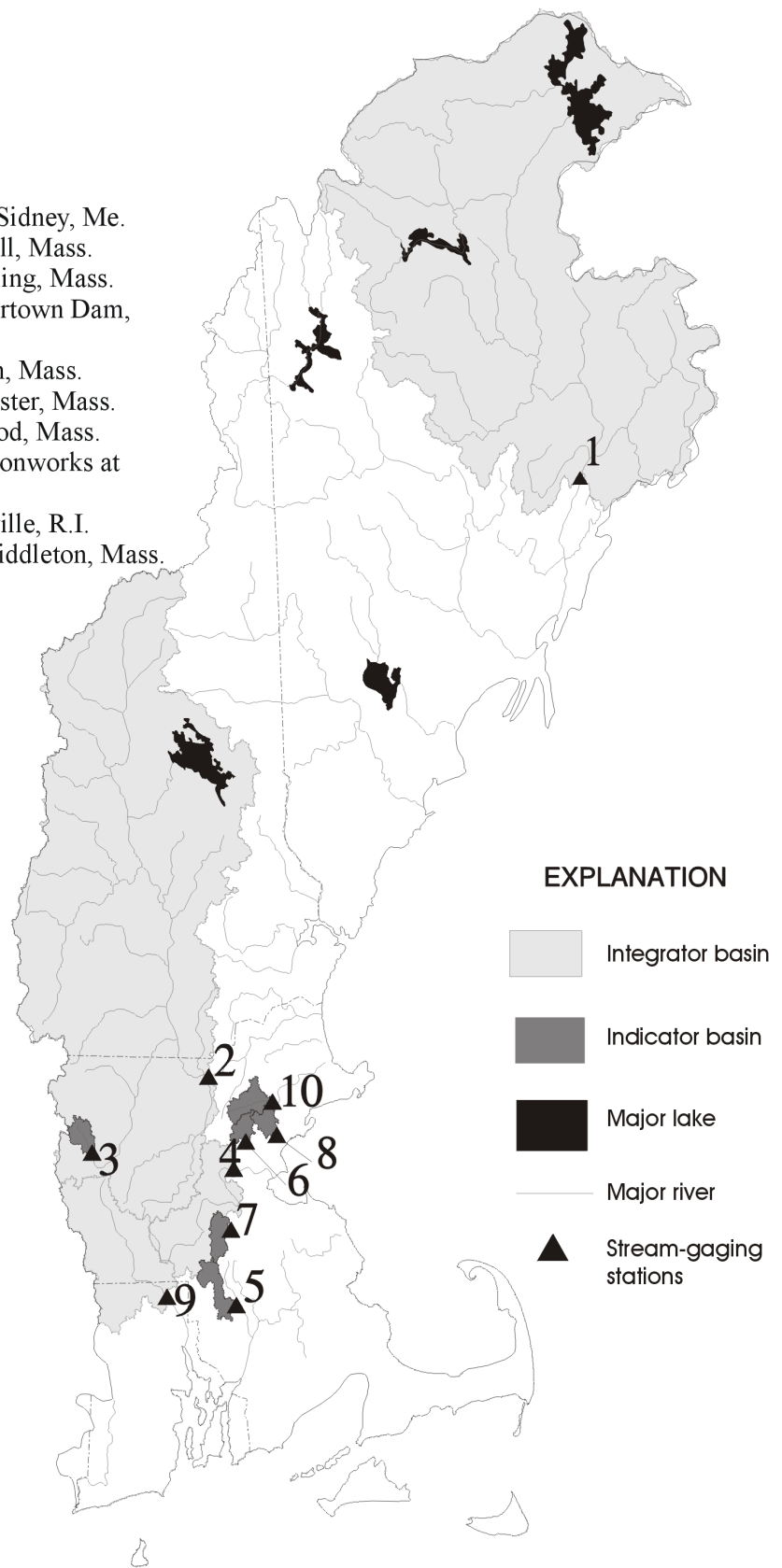


Figure 1. Location of New England Coastal Basins.

Some Results from Basic and Intensive Fixed Site Monitoring in 1999: The following are some results of the 1999 fixed site monitoring:

- Overall, the first year of fixed site sampling went very well thanks to the NECB field crews. Figures 2 and 3 show some nutrient data results for much of 1999; as can be seen for the indicator basins, increasing nutrient concentrations follow the pattern of increasing amounts of urbanization in the watershed. Other constituents, such as conductance, reflect this pattern more strongly. For integrator basins, the Blackstone River stands out as having higher nutrient levels than the other three rivers. Wastewater effluent dominates Blackstone flows.
- A variety of pesticides was detected at the intensive fixed sites. Due to the unusual, droughty, rainfall patterns in 1999, pesticides were rarely detected during the summer. The majority of detections and the highest concentrations were found in May when there were more frequent rains.
- More than 24 VOCs were detected at each intensive fixed site (figures 4 and 5). Ten or more were found in greater than 50 percent of the VOC samples. Data for toluene are suspect because of known contamination problems at the laboratory. MTBE was found in all samples from the Aberjona and greater than 90 percent of the Charles River samples
- The number of rainfall/high flow-related samples collected was less than the number we had hoped to collect during the year. Reasons for this include: the spring and summer of 1999 was an extremely dry period; rain that did occur was usually isolated and scattered which made rainfall sampling very difficult especially for the indicator sites; spring runoff was much less than normal due to a combination of low snowpack in the headwater areas and the lack of significant rains in the spring.

Potential Reports from the NECB Fixed Site Network: One or more USGS WRIR reports will be prepared that summarizes the results of the fixed site network.

Figure 2. Draft Median Total Nitrogen Results for NECB Indicator Sites.

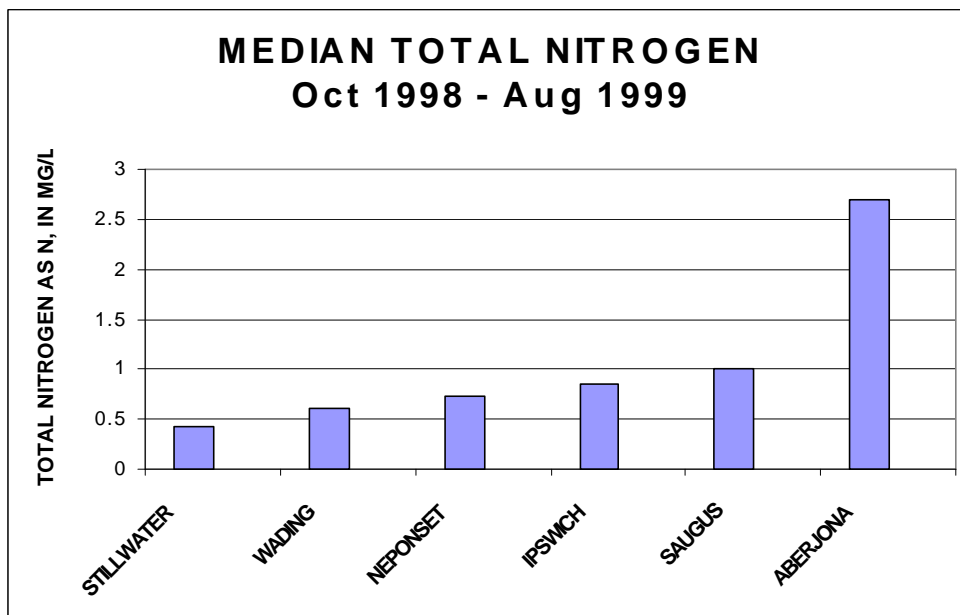
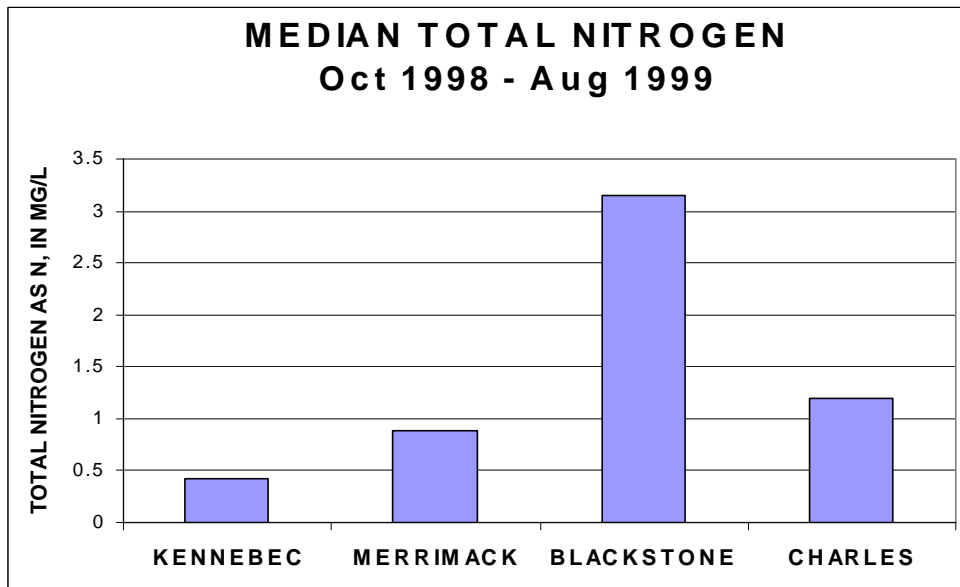
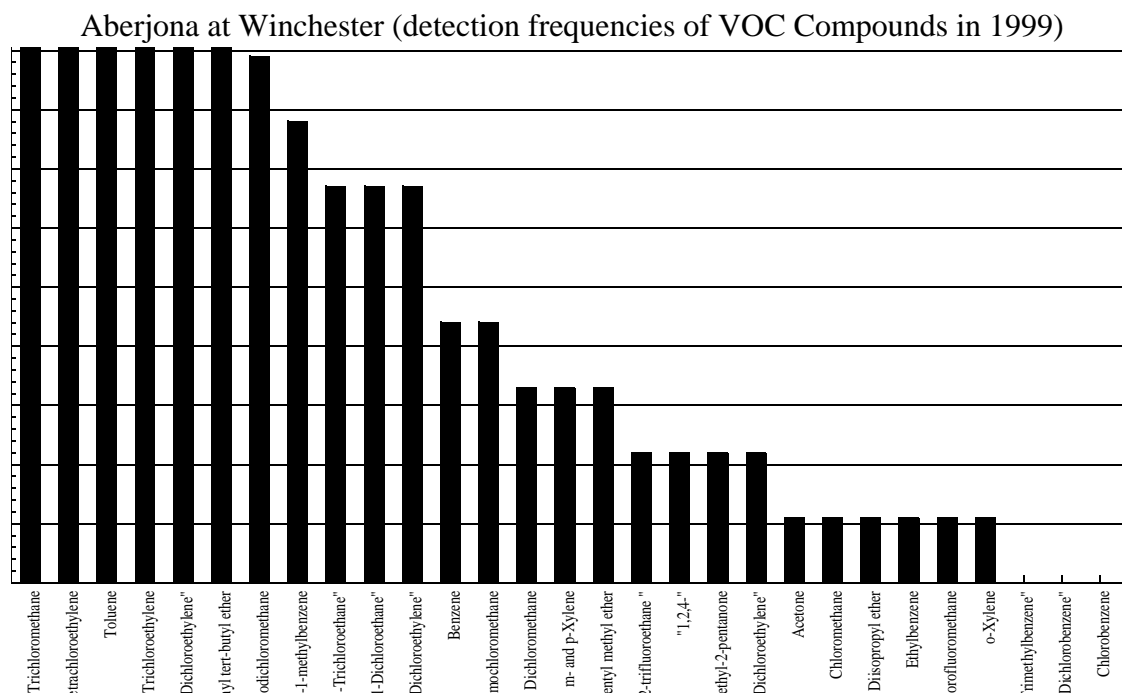
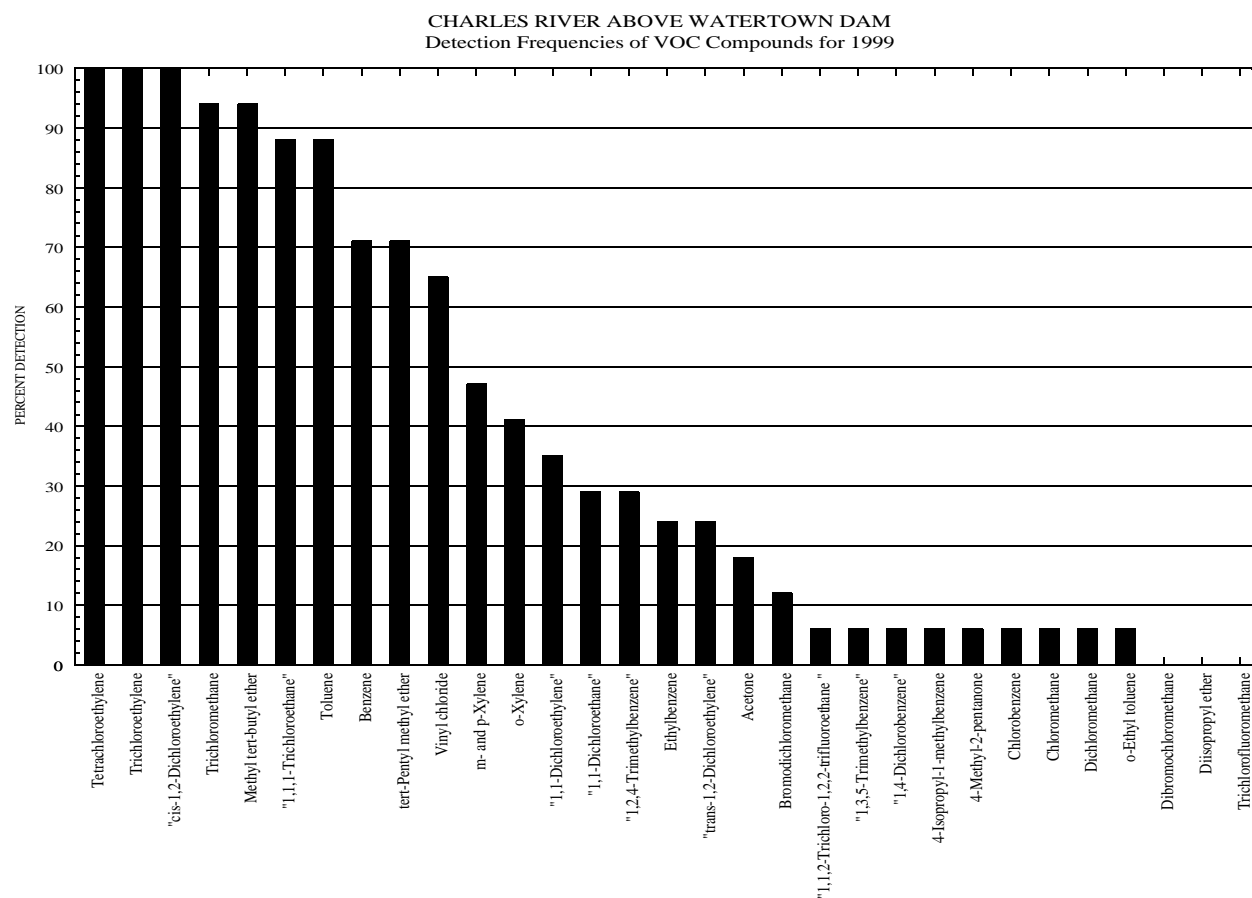


Figure 3. Draft Median Total Nitrogen Results for NECB Integrator Sites.





Figures 4 and 5. Draft VOC results for the New England Coastal Basins intensive indicator and integrator sites, 1998-1999.



BED SEDIMENT AND FISH TISSUE OCCURRENCE SURVEY

For more information on the bed sediment and fish tissue work, contact Ann Chalmers or Jim Coles

The Occurrence Survey for bed sediments and fish tissue (BS&T) was completed in 1999. In September, 1998 BS&T samples were collected at all six indicator sites and 3 additional sites that were considered as potential indicator sites. Sampling of the four integrator sites and the Androscoggin River in Maine was done in the Summer, 1999 (table 3). Fish tissue was not collected at two sites (Wading and Aberjona Rivers) because insufficient numbers of the target taxa could be found.

In addition, 10 of the 14 BS&T sites were sampled for mercury in the water column, sediments, and fish tissue as part of ongoing work with Dave Krabbenhoft's national mercury study and Trace Elements Synthesis Team (TEST).

Summary of BS&T Occurrence Survey Work

	Bed Sediment	Tissue
Number of sites sampled for trace elements and organics	14	12
How many replicate sites for bed sediment & tissue samples are to be analyzed	1	0 (not enough fish for a replicate)

National Target taxa to be analyzed -- White sucker is the target taxa. (Smallmouth bass were collected at two sites that did not have any white suckers).

Some Draft Results from Bed Sediments and Fish Tissue Monitoring in FY98 and 99: Bed sediment was collected at nine indicator basins and fish tissue at seven indicator basins in 1998. Bed sediment and fish tissue was collected at five integrator basins in 1999. Sites were selected over a gradient of 1 to 68 percent urban land use.

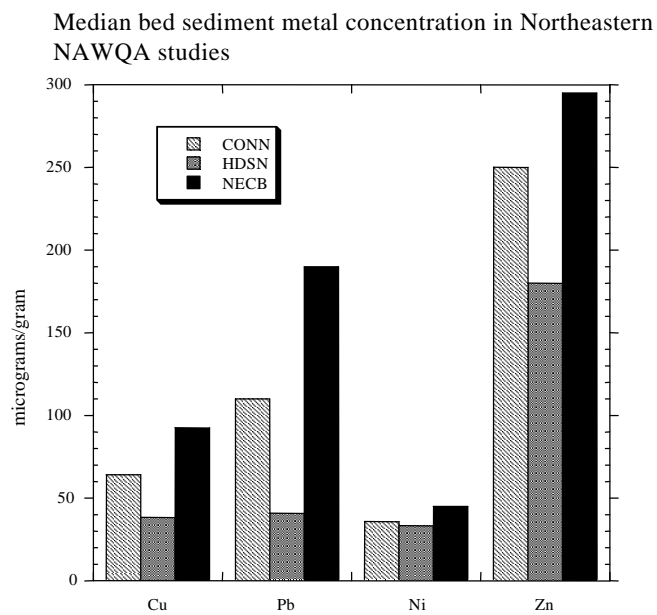
Several factors were investigated for their effects on contaminant concentrations at the sites. Principal component analysis (PCA) indicated that the variables most important for organic compounds in bed sediment in our basins (that is, showed the greatest variance among sites) were basin size, percent wetlands, and percent urbanization. Of these factors, urbanization appears to have the greatest influence in contaminant concentrations at the sites, based on a constrained ordination. Organic compounds and trace elements are both correlated with population density, however the correlation was much stronger in bed sediment than in fish tissue, and for integrator basins than indicator basins. Median concentrations of trace elements in bed sediment were consistently higher for the NECB study than for other northeastern NAWQA study areas (figure 6), but not so high when normalized for organic content in the sediments. Correlation between sediment and fish tissue does not appear to be significant.

Potential Reports from the Bed Sediments and Fish Tissue Occurrence Survey: NECB study staff are currently reviewing and analyzing the bed sediments and fish tissue results from FY98 and 99, and a draft USGS report is being prepared.

Table 3. Locations sampled as part of the Bed Sediments and Fish Tissue (BS&T) Occurrence Survey

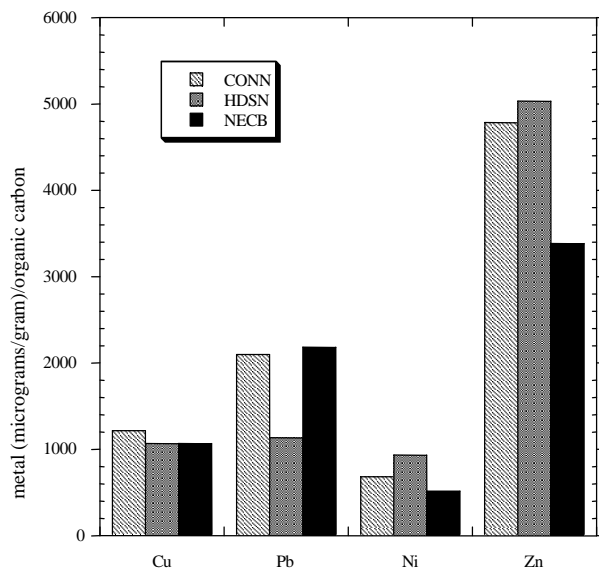
Station Name	Sampled
STILLWATER RIVER NEAR STERLING, MA	bs&t
WADING RIVER NEAR NORTON, MA	bs
WOONASQUATUCKET RIVER AT CENTERDALE, RI	bs&t
NEPONSET RIVER AT NORWOOD, MA	bs&t
MOSHASSUCK RIVER AT PROVIDENCE, RI	bs&t
IPSWICH RIVER AT SOUTH MIDDLETON, MA	bs&t
SAUGUS R AT SAUGUS IRON WORKS AT SAUGUS, MA	bs&t
ABERJONA RIVER AT WINCHESTER, MA	bs
BEAVER BROOK AT N. PELHAM, NH	bs&t
KENNEBEC RIVER AT NORTH SIDNEY, ME	bs&t
Androscoggin River near Lisbon Falls, ME	bs&t
MERRIMACK RIVER BL CONCORD RIVER AT LOWELL, MA	bs&t
CHARLES RIVER ABOVE WATERTOWN DAM AT WATERTOWN, MA	bs&t
BLACKSTONE RIVER AT MANVILLE, RI	bs&t

a.



b.

Normalized median bed sediment metal concentrations in Northeastern NAWQA studies



Figures 6a and 6b. Some NECB bed sediment results compared to other northeastern NAWQA study units.

LAKE CORING

In FY00 Pete Van Meter and Ted Callender will be conducting sediment coring work in the NECB study unit. The purpose of the lake coring is to evaluate long-term trends in lake sediments for pesticides, metals, and other industrial waste by-products. Four lakes were coring in the Boston metropolitan area in late July 2000. In addition, coring will be done in August/September 2000 in New Hampshire and Maine to address long-term trends in arsenic in lake sediments. This coring is linked to studies being done by the U.S. Geological Survey.

URBAN LAND USE GRADIENT STUDY

For more information contact Jim Coles or Keith Robinson

The design of the NECB urban land use gradient (ULUG) study is based primarily on concepts developed by the NAWQA program that are designed to assess how gradients of land use impact water quality conditions. The ULUG study is currently a 3-year effort (1999-2001) that will assist the NAWQA program in determining how to assess the impacts on land uses on water quality. We have also incorporated the design of our fixed-site indicator sites into this study as these indicator sites already represent a gradient of urbanization in eastern Massachusetts. In addition, other studies have been linked to our ULUG study design; these others studies include the:

- University of Connecticut Projects NEMO (Nonpoint Education for Municipal Officials) and NAUTILUS (Northeast Applications of Usable Technology in Land Use Planning for Urban Sprawl) designed to improve nonpoint source education for governmental officials and quantitative assessments of urban sprawl. These projects are funded by USEPA and NASA. Project NEMO has been implemented in many locations across the country by states and local planning agencies, while Project NAUTILUS is being implemented in portions of New England and New Jersey. We have co-located some of our gradient watersheds in areas where these projects are underway, and provide environmental response data to issues of urban sprawl (<http://resac.uconn.edu>)

- the NECB study's mercury study;

- USGS Geologic Division's Clean Water Action Plan (CWAP) funded study *Quantification of human-induced change to the geochemistry of surficial materials in selected urban centers of the US.*

- NAWQA lake coring activities will likely be in 1 or more of the gradient watersheds

- Identification of viral indicators in urban waters with the Massachusetts Department of Environmental Protection Wall Experiment Station.

The proposed schedule of events for the NECB ULUG include:

Task	FY00				FY01			
	1 st quarter	2 nd	3 rd	4 th	1 st	2 nd	3 rd	4 th
1. Complete basin selection	X							
2. Finalize budget and work plan	X							
3. Install pressure transducers at sites		X	X					
4. Initiate QW sampling (March-May)		X	X					
5. Reach delineation (June-July)			X	X				
6. Fish survey (August-Sept); collect fish samples for Hg				X				
7. Habitat survey (August-Sept) ,				X				
8. Invertebrate and algae survey, sediment sample for Hg				X				
9. Round 2 of QW sampling (August-Sept)				X			X	X
10. Trace metals in sediments								
11. Remove pressure transducers					??		??	??

Description of Gradient Study Activities:

Most of the study activities discussed below involve work to be done in 2000. However, a number of spin-off studies may be performed in 2001. These potential studies will be a focal point of discussion during a March 2000 meeting to be held in NH. This meeting will involve a number of USGS researchers that are linking their studies to the NECB gradient design.

1. Site Selection and Characterization: Site selection was completed by the end of December 1999 for the gradient sites (figure 7). The gradient study will include 32 sites; 6 of these are presently indicator basins, 25 are core gradient sites in the study area, and 1 site is located in Connecticut to coincide with a Project NEMO study watershed. Following the selection of sites, watershed and urban features/indices will be calculated and an urban index will be developed.

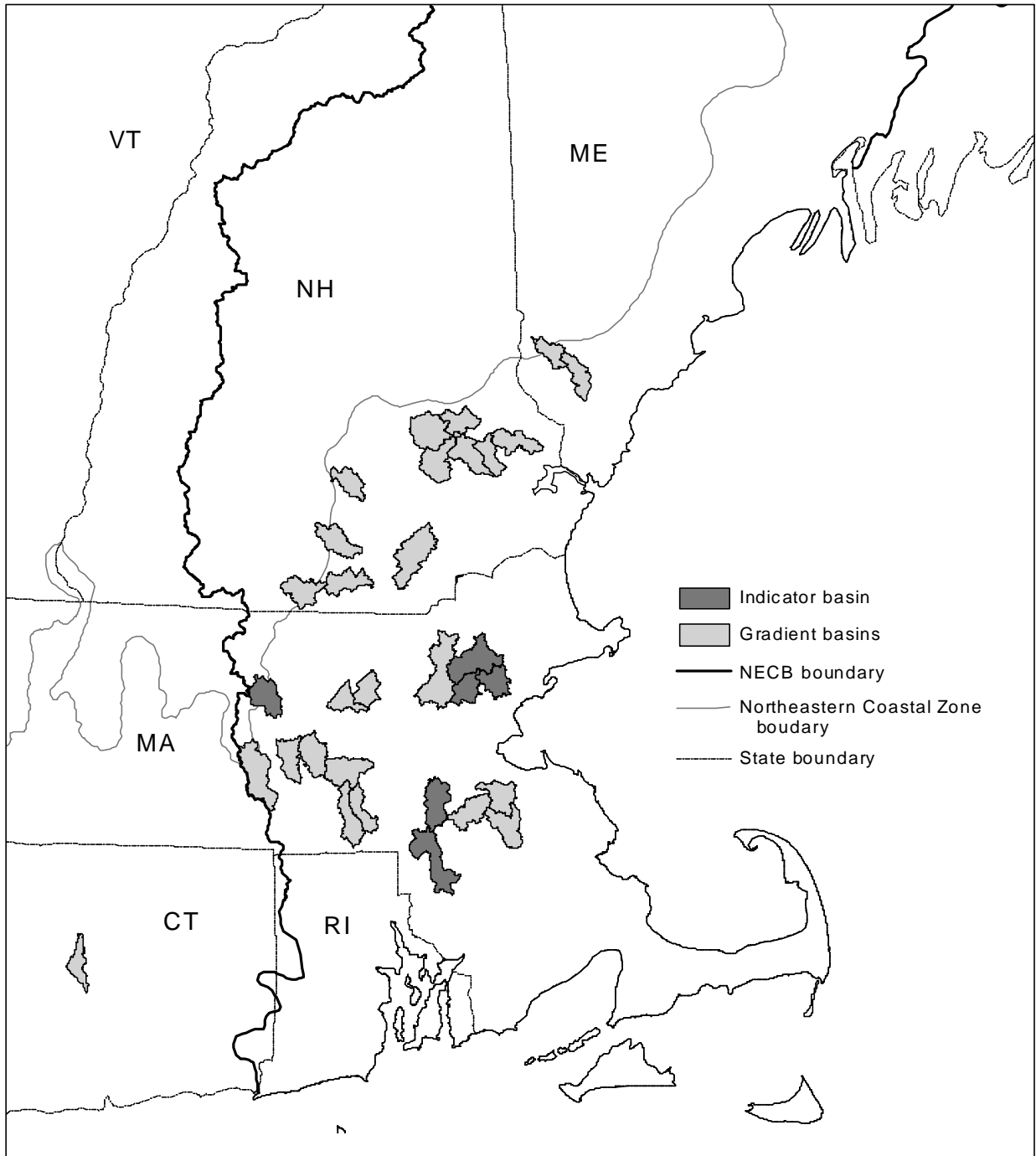


Figure 7. Map shows indicator and gradient basins in the New England Coastal Basins study unit.

2. Hydrologic Data Collection: All sites which are part of the ULUG will have flow/stage measured in some fashion. Either the site will have a continuous recording stream gage for flow measurements or a continuous recording submersible pressure transducer to measure stage in the stream. Stream stage will be determined every 15 minutes by the pressure transducers. The transducers were installed in April/ May, 2000 and may be left installed for 1 year.

3. Water-Quality, Fish Tissue, and Sediment Sampling: All ULUG sites will be monitored for water quality, bed sediment quality, and limited fish tissue analysis (mercury only). For water quality, all ULUG sites will be sampled twice during the period March 2000 - September 2000. Gradient sites that are part of the NECB basic-fixed site network will be monitored monthly or more frequently. For the remaining 26 sites, the 2 water-quality monitoring events will occur during high base-flow conditions in April-May and in August to coincide with ecological monitoring and low flows. This monitoring will collect samples for nutrients and pesticides, as well as field measurements for pH, DO, conductance, and alkalinity. VOC sample collection will also be performed at all sites in coordination with the NAWQA VOC Synthesis Team and the Oregon Graduate Institute which will analyze the samples. In addition, one set of water column samples will be collected for the NECB mercury study and analyzed for total and methyl mercury, sulfate, and DOC. Continuous water temperature will also be collected. Also, all sites will be monitored for bacteria and viral indicators. The NECB study will collect the samples and the Massachusetts DEP Wall Experiment Station in Lawrence MA will perform the sample analysis.

Two sediment quality collection activities will be performed at the ULUG sites. In 2000, we plan to collect whole (unsieved) sediment samples for total and methyl mercury analysis. These samples are a composite and will be collected when the invertebrate/algal survey is performed. The second set of sediment samples to be collected at each site will be for trace metals and will be collected in 2001. At this time, we expect that NECB staff will collect the trace element samples and the analysis will be done as part of the USGS Geologic Division's CWP study "*Quantification of human-induced change to the geochemistry of surficial materials in selected urban centers of the US*". Also in 2000, we are planning to collect fish tissues samples for methyl mercury; see the section on the NECB Mercury Study for a more thorough discussion of this effort.

4. Ecological Sampling: All ecological sampling will be performed in the summer 2000; this includes the reach delineations, and surveys for fish, habitat, invertebrates and algae. Ecological work will follow full NAWQA protocols. Each of these major activities will be completed by separate crews, many of which will be in the field simultaneously.

Potential Reports from the Urban Land Use Gradient Study: A potential large number of reports could be prepared as a result of the gradient study. These reports could describe the results of the various field and watershed characterization data collection efforts and involve both NECB and other NAWQA staff. More discussion on potential reports will be held during the March meeting in New Hampshire. As this time, the primary report from the NECB study would describe the overall results of the gradient study in terms of water quality and ecological variable response to the watershed urban indices. Multi-variate statistical analysis would be used to identify the results.

NECB MERCURY STUDY

For more information on this study contact Ann Chalmers

This study will be done in mutual collaboration with Dave Krabbenhoft of the USGS Toxics Substances Hydrology Program. The NECB mercury study will be an extension of the National Mercury Pilot Study conducted by Dave Krabbenhoft and the Urban Land Use Gradient study (ULUG). The National Mercury Pilot Study collected 106 samples from 21 basins across the country, including 5 sites in the NECB study area. Results of the national study showed that some of the highest mercury concentrations in the country were in the NECB study area. Methylation efficiency, as estimated by MeHg/HgT, was enhanced at NECB sites with low urbanization and high wetland density. Atmospheric deposition was identified as the dominant source of mercury in the NECB study area.

To better define the Hg atmospheric depositional gradient north of Boston, 22 streams were sampled in 1999 for HgT and MeHg in water and sediment on a north south transect from northeastern MA to central ME. Five of the streams sampled in 1999 are located several miles upstream or downstream of ponds sampled for the MADEP Merrimack Valley Fish Study. MADEP sampled 27 lakes/ponds upwind and downwind of local incinerators to attempt to define regional vs local atmospheric mercury sources, and to verify predicted high deposition zones. In 2000, 30 sites will be sampled for HgT and MeHg in water, sediment and fish tissue in coordination with the urban gradient study (figure 8). The ULUG sites include a range of types and intensities of mercury sources which could provide information about how the urbanization of ecosystems effects the production and accumulation rates of methyl mercury.

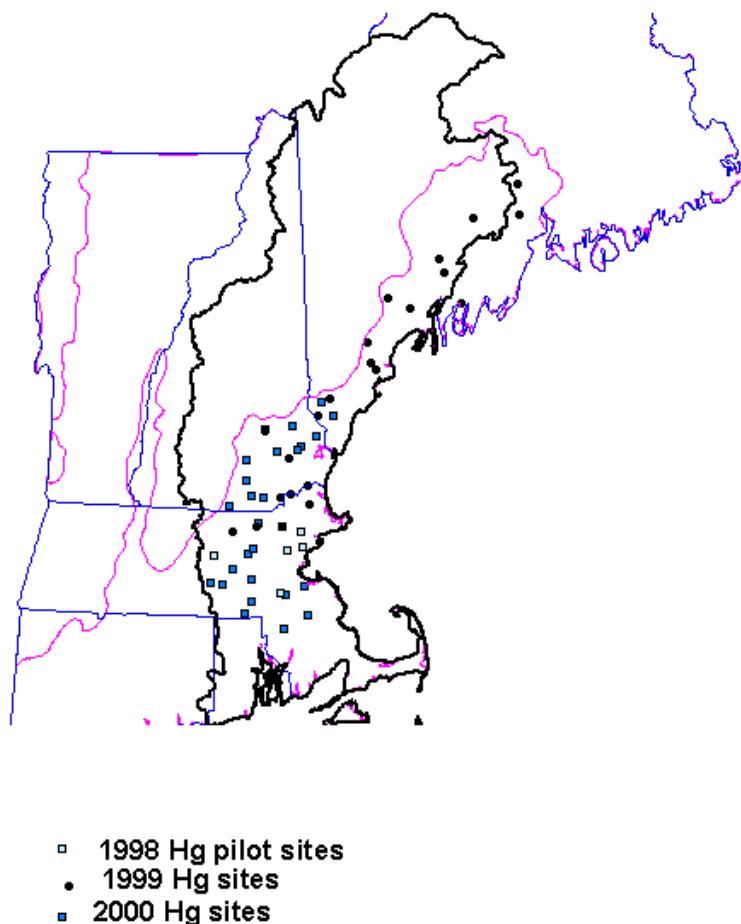


Figure 8. Mercury (Hg) sampling sites in the New England Coastal Basins study unit

The objectives of the NECB mercury study include:

1. Describe the distribution of Hg_T and MeHg data for multiple media, water column, bed sediment, and fish tissue in a gradient of urban settings.
2. Identify ecosystem characteristics associated with the production and accumulation rates of MeHg in a range of urban settings.
3. Provide Hg_T and MeHg data for various input sources to determine if some mercury sources are more likely to become methylated than others.

Results from this study will provide information to guide policy decisions related to air quality standards, fish consumption advisories, land management practices, and wildlife protection programs.

Sampling protocols will be those used for the National Mercury Pilot Study. Sediment, water and fish tissue samples will be collected during summer low flow conditions within several weeks of each other to show patterns of MeHg accumulation, partitioning, and biomagnification relative to site conditions. Water samples will be collected with trace-element clean methods. Water grab samples will be taken at the centroid of flow using clean-hands dirty-hands techniques. Sediments will be collected from the top 2-3 cm depositional zones following NAWQA guidelines for collecting stream bed sediment. Predator

species may be collected for comparison to fish results from other parts of the country. Pumpkinseed and other predator species approximately 2-3 years of age will be rinsed, measured for length, weighed and put in ziplock bags on dry ice.

Hg_T and MeHg, sulfate, DOC and DOC fractionation will be determined from water column samples, Hg_T and MeHg, AVS/SEM (acid-volatile sulfides/ simultaneously extracted metals) and LOI (loss on ignition) will be determined from sediment samples, and Hg_T will be determined from fish fillets. Analytical procedures will be the same as established for the National Mercury Pilot Study.

Potential Reports from the Mercury Study: At this time we are considering one report that would summarize the entire mercury study. Preparation of this report by Ann Chalmers (lead author) will be started in 2001 with assistance from Dave Krabbenhoft. The form of the report will likely be a journal article.